-2 pcts

Method and device for identifying the type of discharge lamp

The invention relates to a method and a device for identifying the type of discharge lamp, in particular the type of low-pressure gas discharge lamp.

Identification of the type of discharge lamp, particularly the type of low-pressure gas discharge lamp, is utilized in so-termed universal ballasts that are capable of controlling different types of discharge lamps within a broad power range. Said identification is frequently based on different characteristics or parameters of the lamp, such as the I-V characteristics (WO 00/07415), the resistance of the incandescent wire (EP 0889675), the light output at different currents/voltages (EP 0759686), the starting voltage (EP 0413991) and combinations thereof.

None of these known lamp type identification methods, however, gives a definite answer about the type of lamp that is actually connected to the universal ballast, so that there is a need for yet other methods of identifying the lamp type, which can be used supplementary to the known methods and possibly in combination with said methods to provide a higher degree of certainty that the type of discharge lamp is correctly identified.

Therefore, it is an object of the invention to extend the above-mentioned possibilities of lamp identification.

Applicant has found that by applying an amplitude-modulated control current to a fluorescent lamp at the rising edge of the envelope of the modulated control current, a voltage response of the lamp is obtained the peak value of which exhibits a connection with the length and the diameter of the lamp. By measuring this peak voltage, it is possible to identify the type of lamp used.

The method of identifying the type of discharge lamp in accordance with the invention is characterized in that it comprises the steps of applying an amplitude-modulated control current to a discharge lamp, detecting the peak value of the lamp voltage at a rising edge of the envelope of the modulated control current, and comparing the detected peak

value with previously recorded peak values for different lamp types, and assigning the detected peak value to a lamp type on the basis of said comparison.

The device in accordance with the invention for identifying the lamp type, which comprises means for supplying a control current to a discharge lamp, is characterized by means for amplitude-modulating the control current to the lamp, peak detection means for detecting the peak voltage across the lamp at a rising edge of the envelope of the amplitude-modulated control current, recording means for recording peak voltages associated with lamp types and means for comparing the measured peak voltage with the recorded peak voltages and supplying a lamp type-indicating signal on the basis of said comparison.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiment(s) described hereinafter.

In the drawings:

Fig. 1 shows the reaction of the lamp voltage to a step in the envelope of the lamp control current,

Fig. 2 shows a general block diagram of a ballast with a discharge lamp to which the invention can be applied,

Fig. 3 shows a number of measurement-based characteristics of the peak voltage as a function of the modulation frequency for discharge lamps of different diameters,

Fig. 4 shows a number of measurement-based characteristics of the peak voltage as a function of the modulation frequency for lamps of different lengths.

Applicant has carried out experiments in which a preferably square-wave modulation signal having a comparatively lower frequency supplies an amplitude-modulated control current having a comparatively higher frequency to discharge lamps of different lengths/diameters, and the peak voltage occurring across the lamp at a rising edge of the envelope of the amplitude-modulated control current is observed and measured.

Fig. 1a shows an illustrative reaction of the lamp voltage Vl to a positive step in the envelope of the control current Il.

If, as is customary, a control circuit for supplying a control current is used that behaves as a current source, the electric field within the lamp and hence the lamp voltage will adapt itself to the current demand at a specific point in time.

If a square-wave modulation signal with rising edges is employed, then the voltage across the lamp will exhibit dynamic behavior during the rising edge that deviates from the behavior that would be predicted on the basis of the static negative V-I characteristic of the lamp. By increasing the control current of the lamp by one step, the electric field within the lamp will increase, since there are not enough charge carriers to supply the current demanded, so as to produce more charge carriers by ionization. This manifests itself as a peak in the lamp voltage, after which the lamp voltage decreases because the additional production of charge carriers causes the resistance of the charge to decrease. After the peak in the lamp voltage, the discharge will find an equilibrium at a lamp voltage which is lower than that before the step in the control current, which equilibrium is in accordance with the negative V-I characteristic of the discharge (Fig. 1a).

In an experiment, a control voltage having a frequency close to the resonance frequency (40 kHz in a practical case) was supplied to the resonant lamp circuit comprising a self-inductance connected in series with the lamp and a capacitor connected in parallel with the lamp. The lamp electrodes were not heated externally and the lamp was ignited by increasing the amplitude of the control voltage. In accordance with the invention, the control voltage was amplitude-modulated by a square-wave signal having a modulation depth of, for example, 0.5 V peak-peak. The modulation frequency was varied over a range from 200 Hz to 5 kHz. The experiment was repeated for different lamp types: T8 36W, T12 40W, PLL 40W, T5HO 39W, all having approximately the same length of approximately 100 cm and (outside) diameters of approximately 2.5 cm, 3.8 cm, 1.7 cm and 1.6 cm, respectively, and PLC 18W having a smaller length of approximately 34 cm and an (outside) diameter of approximately 1.2 cm (type indication from Philips Lighting).

The peak voltage across the lamp was measured during the positive edge of the modulation signal, i.e. the rising edge of the envelope of the modulated control current supplied to the lamp.

Results of repeated experiments are shown in Figs. 3 and 4.

Upon applying a square-wave modulation, a peak voltage across the lamp was observed from the point where the control current increases. This peak voltage, being a reaction to the step in the control current, decreases linearly with the modulation frequency. Fig. 3 shows the peak voltage Vp as a function of the square-wave modulation frequency bmf for different lamp types having the same length and different diameters. As the Figure shows, the peak height decreases with increasing modulation frequency. The upper characteristic (T5) remains substantially constant but decreases at modulation frequencies higher than the

highest modulation frequency shown, i.e., 1000 Hz. (The vertical line segments in Figs. 3, 4 indicate measuring error ranges for measurements on the same lamp type.) A number of lamps of the same lamp type were examined, inter alia, to find out whether ageing of the lamp plays a role; it turned out that this was not the case.

The peak height as a function of the modulation frequency is dependent on the lamp diameter that decreases in the series from P12, P8, PL-L to T5. At a certain modulation frequency the peak height increases as the diameter decreases or decreases as the diameter increases, and the lamp types can be distinguished by the height of the peak voltage.

In Fig. 4, a PL-C 18W and a T5HO 39W were compared. The diameters of these lamps are approximately the same, but the length of the PL-C lamp is approximately half that of the T5 lamp. The Figure shows that the peak height increases with increasing lamp length.

It has been found that lamp stabilization or the operating history of the lamp does not noticeably influence the characteristics shown, and that the effect of the value of the lamp current on the peak height is much smaller than the effect of the modulation frequency or the lamp type.

A possible explanation for the decrease in peak height with increasing lamp diameter (Fig. 3) and modulation frequency is given hereinbelow. The peak value of the electric field that must be generated within the lamp does not only depend on the lamp current but also on the amount of electrons present and the electric field just before the step-like increase of the lamp current. This is the result of course of the step-like decrease which, in the case of square-wave modulation, precedes the step-like current increase. When the step-like current decrease occurs, the discharge has too many charge carriers in comparison with the current demand. As a result the electric field will decrease suddenly to reduce the number of charge carriers produced. Subsequently, the lamp will follow the negative VI characteristic thereof and the lamp voltage will increase to a value exceeding the value before the step-like decrease of the control current. This process, which strives to achieve an equilibrium between electron loss by ambipolar diffusion and the production of electrons by ionization requires some adaptation time. This adaptation time is longer as the diameter of the lamp is larger. If the adaptation time has not yet elapsed when the positive step in the control current occurs, then a small increase of the electric field, immediately after the positive step occurs, will be sufficient to produce the number of charge carriers demanded by the increased control current. This also applies if an increase of the modulation frequency takes place, in which case the time between a negative and a positive step in the control

current decreases and hence less adaptation can take place. The increase of the peak voltage with increasing length of the lamp can be attributed to the fact that the peak voltage is calculated from the product of the increase of the electric field and the length of the lamp.

Fig. 2 shows a block diagram of a universal ballast to which the invention can be applied, which ballast is used for a discharge lamp La and comprises a lamp capacitor C, a series self-inductance L and a dc blocking capacitor Cdc, a device for electromagnetic compatibility (EMI) and power factor correction (PFC), which device can be connected to the electricity grid and to which a high-frequency source (HF) for feeding the series-resonance chain L-C is connected via a direct-current connection DC.

A microcontrol unit mP controls the device EMI/PFC embodied so as to be, for example, a voltage-increasing AC/DC converter and the HF source embodied so as to be, for example, an inverting half-bridge converter (inverter), so that during normal operation a square-wave, comparatively high-frequency supply voltage (40 kHz) is supplied to the series-resonance chain L-C at approximately the resonance frequency thereof, so that a corresponding control current is supplied to the lamp. In this case, the series-resonance chain serves as a current source.

In accordance with the invention, a peak voltage detector PD is connected to the lamp La, the indication result of said peak-voltage detector being supplied to the microcontrol unit mP.

The square-wave modulation of the control current of the lamp, which is necessary to carry out the invention, can be obtained in a number of different ways.

1. A frequency modulation.

In this case, the HF source supplies a comparatively high-frequency square-wave signal of constant amplitude and operating cycle, which is frequency-modulated by a comparatively low-frequency square-wave modulation signal. Due to the properties of the series-resonance chain L-C (above resonance the impedance increases at a higher frequency so that the lamp current decreases) the lamp current is modulated with the same waveform. This can be achieved using customary, dimming, fluorescence lamp control circuits employing control methods such as on-time control, frequency control or phase control, as well as by suitably programming the microcontrol unit mP for carrying out corresponding control methods of the HF source.

2. Supply voltage modulation (VSM).

In this case, the HF source generates a HF voltage at a constant frequency which is amplitude-modulated with a square-wave modulation signal by modulating the voltage of the

DC bus. This requires an input stage PFC which can supply a variable voltage to the HF source, which variable voltage can be obtained by using a so-termed SEPIC or retrace converter.

3. Pulse width modulation (PWM).

In this case, the HF source supplies a HF signal having a constant frequency and amplitude but a variable operating cycle. By reducing the operating cycle, the effective value of the voltage to the lamp resonance chain L-C and hence the lamp current can be reduced. The operating cycle can be modulated with a square-wave modulation signal to obtain the square-wave modulated lamp current required to carry out the invention.

The microprocessing unit mP can have an internal or an external memory for storing a table of lamp voltage peak values associated with different lamp types, which peak values are calibrated for one or a number of square-wave modulation frequencies bmf at a given modulation depth of the lamp control current or a number of modulation depths. By comparing the peak voltage detected by the peak voltage detector PD at a given bmf and modulation depth, it is possible to identify the lamp type that can be connected, which data can be used to set parameters of the universal lamp ballast which are suitable for this lamp type.

It is noted that the above description regarding the manner of generating the square-wave lamp control current enables persons skilled in the art to suitably program the microcontrol unit mP for controlling the HF source in a desirable manner, the more so as, for example, for dimming a discharge lamp corresponding control algorithms are used already.